TELTONIKA

TM2 GSM/GPRS module
User Manual

# User Manual

TM2 GSM/GPRS Module

## History

Company was established on 15th of April 1998. Main residence is based in Vilnius.

ompany started with production of telecommunication devices.
In 2001 company expanded its fields of activity by starting design and manufacturing of electronical systems for wireless data transfer.

In 2002 contract of partnership and collaboration was signed with company Pro-Sign GmbH (Germany), considering design and representation of graphic programming interface iCon-L in Eastern Europe.

In 2003 Teltonika and NOKIA became partners and started integration of NOKIA M2M technology using NOKIA N12 module. It was the beginning of wireless technology development process.

In 2004, NOKIA invited Teltonika to join presentation of M2M technology innovations in CeBIT 2004. It was very high evaluation of a small Lithuanian company and its possibilities, which helped to feel peculiarities of international business.

In 2004 Teltonika produced more than 10 new products and solutions using EDGE technology. It was a condition that made Teltonika a leader of M2M integration solutions using EDGE not only in Lithuania, but also in Europe.

2005 was the year of two successful international exhibitions: CEBIT 2005 and HANNOVER MESSE 2005. These shows opened new possibilities for offering our products and solutions for all world.

In the year 2005 Teltonika became an international company. We became Lithuanian - Finnish Company. A few employees from NOKIA joined Teltonika's staff. Presently they successfully develop activity of new companies: Teltonika International GmbH (Düsseldorf) and Teltonika International Oy (Helsinki).

## About US

Our vision is to provide added value for people and companies by creating electronical devices and solutions, which are based on the latest achievements of science and technology.

We aim to help people to integrate the latest technologies in real life, what would bring more cosiness, comfort, freedom of mobility and security to their everyday life.

We seek to make all our solutions an inconceivable part of people lives.

# Table of Contents


**1 Document Mission** **3**
1.1 Glossary 3
1.2 Scope of Product 5
1.3 Power Management 5
1.4 Interface 6
1.5 Miscellaneous features 6
**2 Product functions** **7**
2.1 System Features 7
2.2 Modem 10
2.2.1 Mechanical characteristics 11
2.2.2 Power supply 11
2.2.2.1 Current consumptions 12
2.2.2.2 Power Saving 14
2.2.3 GSM/GPRS modem functionalities 15
2.2.4 Supplementary servines 16
2.2.5 Short Message Service 16
2.2.6 SIM Functionality 16
2.2.7 AT-command support 16
2.2.8 Other basic features 16
**3 User Interfaces** **18**
3.1 SIM Interface 20
3.2 Battery 21
3.3 Antenna interface 21
3.4 Asynchronous Serial interface 22
3.5 GPIO 22
3.6 SW interfaces 23
3.7 Audio devices 28
3.7.1 Handset 28
3.7.2 Headset 28
3.7.3 Microphone 28
3.7.4 Hands-free 28
3.7.5 Polyphonic ringer 28
3.7.6 ADC interface / Measurement interface 29
3.7.7 SPI 29
3.7.8 I2C bus interface 29

# 1 Document Mission

The TM2 User Manual provides all information necessary for a successful integration of TM2 module into the application of the customer. Additionally, TM2 User Manual contains all product functions for application.

## 1.1 Glossary

| Abbreviation / Term | Explanation / Definition |
|---|---|
| ADC | Analog-to-Digital Converter |
| ADN | Abbreviated Dialling Numbers |
| AFC | Automatic Frequency Correction |
| AND | Abbreviated Dialing Number |
| AMR | Adaptive Multi Rate |
| API | Application Programming Interface |
| ASC | Asynchronous Serial Interface Controller |
| BCCH | Broadcast Control Channel |
| BDN | Barred Dialing Number |
| CB | Cell Broadcast |
| CBCH | Cell Broadcast Channel |
| CCCH | Common Control Channel |
| CD | Carrier Detect |
| CGU | Clock Generation Unit |
| CLI | Calling Line Identifcation |
| CSD | Circuit Switched Data |
| DAI | Digital Audio Interface |
| DCE | Data Communication Equipment |
| DCS | Digital Cellular System (1800 MHz) |
| DCXO | Digital Controlled Crystal Oscillator |
| DL | Reception |
| DSP | Digital Signal Processor |
| DSR | Data Set Ready |
| DTE | Data Terminal Equipment |
| DTMF | Dual Tone Multi Frequency |
| DTR | Data Transmit Receive |
| EBU | External Bus Interface Unit |
| EFR | Enhanced Full Rate |
| EGSM | Extended - Global System for Mobile Communication |

| | |
|---|---|
| EMS | Enhanced Messaging Service |
| ESD | Electro Static Discharge |
| ETSI | European Telecommunications Standards Institute |
| FDN | Fixed Dialing Number |
| FFS | Flash File System |
| FR | Full Rate |
| GPIO | General Purpose Input/Output |
| GPP | 3rd Generation Partnership Project |
| GPRS | General Packet Radio System |
| GSM | Global System for Mobile Communication |
| HR | Half Rate |
| HW | Hardware |
| IC | Integrated Circuit |
| I2C | Inter-Integrated Circuit |
| IIR | Infinite Impulsive Response |
| IMEI | International Mobile Equipment Identity |
| JTAG | Joint Test Action Group |
| LDN | Last Dialing Number |
| M2M | Machine-to-Machine |
| ME | Mobile Equipment |
| MIDI | Musical Instrument Digital Interface |
| MS | Mobile Station |
| MSC | Multi-Slot Class |
| N-AMR | Narrow-AMR |
| NOM | Network Operating Mode |
| NV | Non Volatile |
| PA | Power Amplifier |
| PC | Personal Computer |
| PBCCH | Packet Broadcast Control Channel |
| PCCCH | Packet Common Control Channel |
| PCS | Personal Communication Service |
| PDP | Packet Data Protocol |
| PDU | Protocol Data Unit |
| PLMN | Public Land Mobile Network |
| PPS | Protocol and Parameter Selection |
| PST | Protocol Stack |
| PWM | Pulse Width Modulation |
| RF | Radio Frequency |
| RTC | Real Time Clock |
| RX | Receiver |

| | |
|---|---|
| SAW | Surface Acoustic(al) Wave |
| SDN | Service Dialing Number |
| SIM | Subscriber Identity Module |
| SMA | SubMiniature version A connector |
| SMS | Short Message Service |
| SMS MO | Short Message Service Mobile-Originated |
| SMS MT | Short Message Service Mobile-Terminated |
| SPMidi | Scalable Polyphony MIDI |
| SPI | Serial Peripheral Interface |
| SSC | Serial Synchronous Interface Controller |
| STK | SIM Toolkit |
| SW | Software |
| TCH | Traffic Channel |
| TX | Transmitter |
| UART | Universal Asynchronous Receiver-Transmitter |
| UL | Transmission |

## 1.2 Scope of Product

TM2 is a small, light weight and low power consumption module that enables digital communications services on GSM/GPRS networks for machine to machine or user to machine wireless applications.

TM2 modules are developed in compliance with internal and normative certification requirements. In particular, they are certified by CE approval report and Radio & Tele Terminal Equipment Directive (R&TTED) report. Requirements for lead-free components are imposed and satisfied.

The product implements a quad-band MS able to operate in the frequency bands GSM 850 MHz, EGSM 900 MHz, and DCS 1800 MHz and PCS 1900 MHz; the dynamic behavior can be configured dynamically by disabling/enabling a specific band e.g. through AT commands. Eventually, the module can be configured either dual-band or tri-band or quad-band.

The supported power classes for both voice and data services will be:

- Class 4 (2W) for GSM/EGSM bands.
- Class 1 (1W) for DCS/PCS bands.

The product implements a Class B Mobile Station; this means the data module can be attached to both GPRS and GSM services, using one service at a time. Network operation modes I to III are supported, with user-definable preferred service between GSM and GPRS.

Ignition: it takes around 800 ms to enter in AT active state (eg AT OK, see picture). From this state we have a 2 seconds setup and stabilization time before the startup signal is sent to the m2m applications.

Minimum RESET time safe value is 120 ms

## 1.3 Power Management

- Battery connector.

## 1.4 Interface

- SIM card holder supporting 1.8 V and 3 V card type.
- MMCX Interface connector for RF output (50 Ohm connector MMCX Edge Mount SMD J01341A0081 (Telegartner)).
- 60 pin board-to-board connector (CVILUX CBRB060PC2000R0): Audio (2x analog, 1x digital), I2C bus, SPI bus, 2x ADC, 2x analog out (PWM), 12 GPIOs.
- 2 UART serial ports.

## 1.5 Miscellaneous features

- 40 tones polyphonic ring tones support.

# 2 Product functions

## 2.1 System Features

A comprehensive list of TM2's features is presented in the following table and further detailed in the following paragraphs. The features can be shared in the following sections:

- Generic features;
- GSM/GPRS modem functionalities;
- Mechanical and Electronics features;
- Software features;
- Accessory support ;
- Host SW tools.

| Set of features | Description |
|---|---|
| Type approval | CE approval report available |
| | Radio & Tele Terminal Equipment Directive (R&TTED) report available |
| Environmental constraints | Requirements for lead-free components |
| Security | Platform security concept description available |
| | Secure IMEI management |
| | Secure flashing environment |
| | Secure memory area |
| Service software API functionality | Software update |
| | Software update using system connector |
| | Module testing SW |
| | Rewrite IMEI |
| | Manage SIM locks |
| | Backup and restore user data |
| | Defect logger to analyze memory trace |
| GSM standard compliancy | ETSI GSM Phase 2+ (R99) |
| Frequency Bands | GSM 850 MHz |
| | EGSM 900 MHz |
| | DCS 1800 MHz |
| | PCS 1900 MHz |
| | Disable band/Manual band selection |
| GSM/GPRS Data Services | GPRS multi-slot class (MSC) 10 (4+1, 3+2) |
| | GPRS PBCCH/PCCCH support |
| | CBCH reception when on PBCCH supported |
| | GPRS Class B and CC |
| | Coding scheme CS-1, CS-2, CS-3, CS-4 |
| | Network operation mode I, II, III |

| Set of features | Description |
|---|---|
| | CSD up to 9.6kbps (V.32, V.110) |
| | FAX G3, Class 2.0 |
| SMS Short message service | Short Message Service Mobile-Terminated (SMS MT) |
| | Short Message Service Mobile-Originated (SMS MO) |
| | SMS-CB Cell Broadcast (SMS CB) |
| | Concatenated SMS |
| | Via GSM or GPRS |
| | Text and PDU mode |
| SIM Functionality | Abbreviated Dialling Numbers (ADN) |
| | Fixed Dialling Numbers (FDN) |
| | Last Dialled Numbers (LDN) |
| | Service Dialling Numbers (SDN) |
| | SIM Lock protection |
| | SIM Toolkit |
| SIM Locks | Network |
| | Network subset |
| | Service provider |
| | Corporate |
| | Operator |
| Basic Mobile Station features | Display of Called Number |
| | Indication of Call Progress Signals |
| | Country/PLMN Indication |
| | Short Message Indication and Acknowledgement |
| | International Access Function |
| | Service Indicator |
| | Dual Tone Multi Frequency (DTMF) |
| | Subscription Identity Management |
| | On/Off Switch |
| | Service Provider Indication |
| GSM Supplementary services | Call Hold (CH) |
| | Call Waiting (CW) |
| | Multi-Party (MTPY) |
| | Call Forwarding (CF) |
| | Explicit Call Transfer (ECT) |
| | Call Barring (CB) |
| | Calling Line Identification Presentation (CLIP) |
| | Calling Line Identification Restriction (CLIR) |

| Set of features | Description |
|---|---|
| | Connected Line Identification Presentation (COLP) |
| | Connected Line Identification Restriction (COLR) |
| | Unstructured Supplementary Services Data (USSD) |
| Audio Codecs | Speech codecs FR (Full rate) / EFR (Enhanced Full Rate) / HR (Half Rate) |
| | Speech codecs AMR (Adaptive Multi Rate) |
| Encryption algorithms | Encryption algorithms A5/1 |
| | Encryption algorithms A5/2 |
| Mechanical features | Number of RF shield required = 1 |
| | Number of PIN's used for SW flashing = 3 (RX/TX and Ground) |
| Connector | RF connector |
| | Board to board connector |
| | SIM holder |
| RTC | Real Time Clock (RTC) supported with alarm capabilities |
| SIM | SIM connector on-board or external |
| | SIM voltage: 1.8 and 3 V |
| | High-speed interface |
| | External SIM ESD protection required. |
| | External SIM connector support |
| Battery | Protection circuitry integrated on the platform |
| | Charging of deeply discharged battery must be possible. |
| | Charging during phone call |
| | Maximum charging current of battery :1100 mA |
| Audio features | Handsfree and headset operation |
| Audio filter types supported | Echo canceller |
| | Noise reduction |
| I/O Interfaces | Maximum number of GPIO-interfaces 12 |
| | Number of UART's 2 |
| | Number of free UART's for user : 1 |
| | One UART with complete 9-pin UART 1 |
| | Max speed UART 921.6 Kbps (default AT commands 115.2 kbps) |
| | One UART with only RX/TX |
| Power on | Power on time (sec) 3 sec |

| Set of features | Description |
|---|---|
| Call Handling | Redial missed and/or received calls (CLI) |
| | Abbreviated Dialling |
| Call phone | Full duplex |
| | Ringtones |
| | Polyphonic ringtones |
| Audio formats integrated with the hardware | HR, FR, EFR, AMR |
| | MIDI 1.0 |
| | iMelody |
| | Number of simultaneous polyphonic tones (without extra HW) 40 |
| Accessory support | Audio headset |
| | Charger |

## 2.2 Modem

The modem part provides with minimal component's list all functionality necessary for voice and data transmission over GSM and GPRS network. The modem is divided in two separated areas surrounded by traces on which metal boxes can be soldered. The first area encloses the RF High power components and the remaining passive components of the transceiver; the second area group's baseband processor, memory, crystals and power management unit.

### 2.2.1 Mechanical characteristics

The Number of RF shield required is 1. For mechanical characteristics of GSM/GPRS module refer to the following:

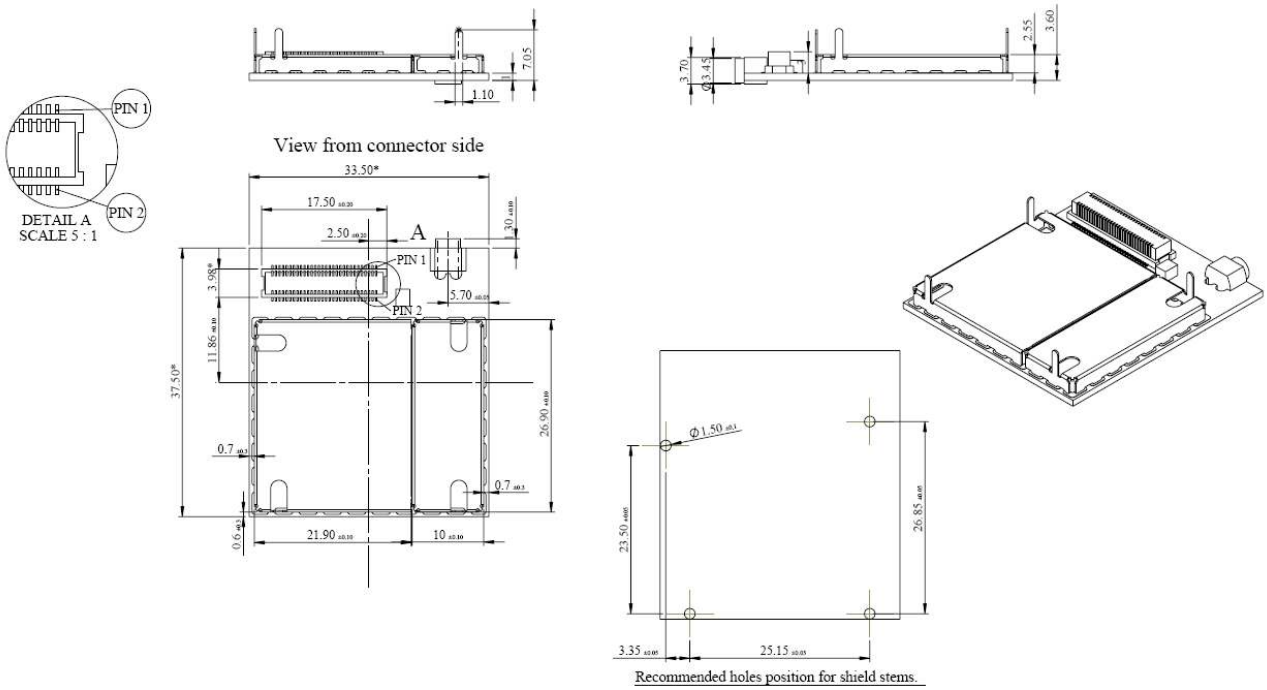



Fig. 2.2.1.1 TM2 Dimensional layout

| Mechanical and environment | Value |
|---|---|
| Size | 33.5 mm x 38.8 mm x 5.6 mm |
| Weight | < 10 g |
| Operating temperature range | From -20°C to +55°C |

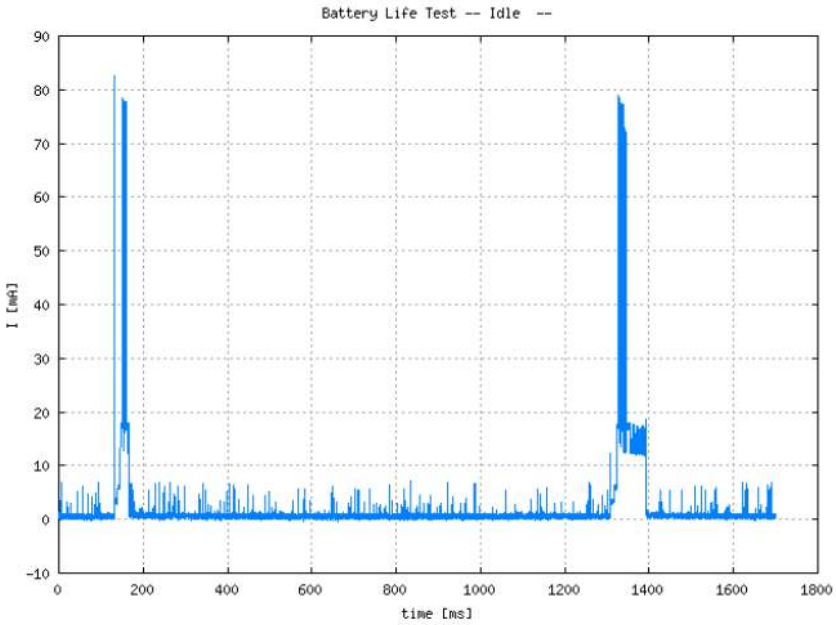
### 2.2.2 Power supply

The on board power supply is derived by CviLux connector that provides a voltage value VBAT on pins 1, 3, 5, 7. The range of VBAT is between 3.5 V and 4.2 V, while typically its value is 3.8 V.

| Description | Min | Typ | Max |
|---|---|---|---|
| Supply voltage | 3.5 V | 3.8 V | 4.2 V |

#### 2.2.2.1 Current consumptions

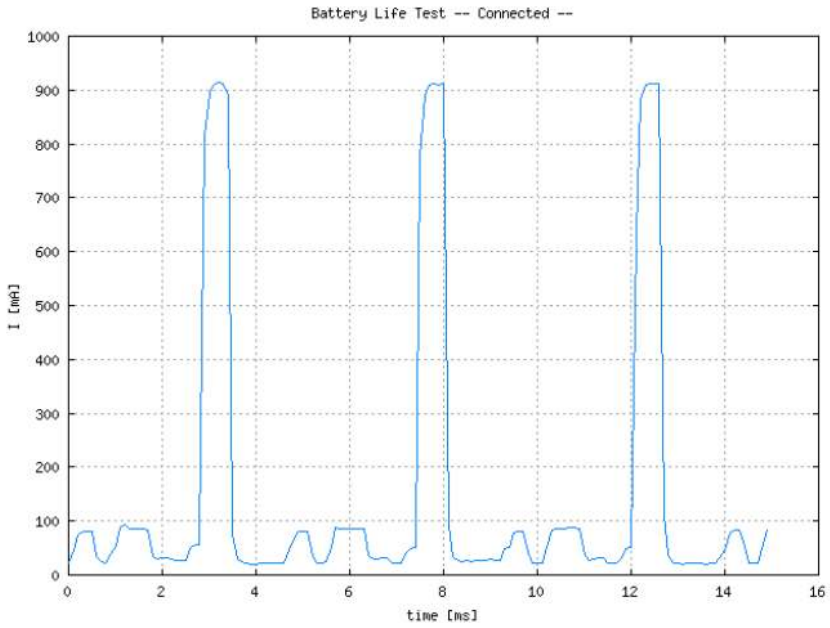
Current consumptions of TM2 module are reported in the following pages. Power OFF current is < 30 μA.
BAND: GSM900
TEST SETTINGS:
DRX: 5;
BA LIST arfcn: 1 9 17 26 34 42 50 58 67 75 83 91 99 108 116 124;
PCL: 5.




**GSM900**

**Idle mode**

Average current:
1.45 mA

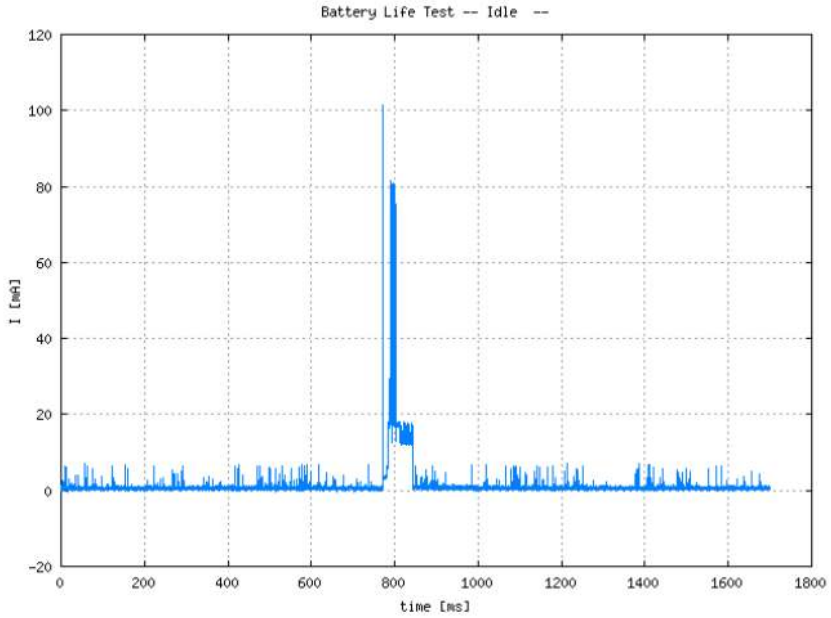



**GSM900**

**Allocated mode**

Average current:
147.13 mA

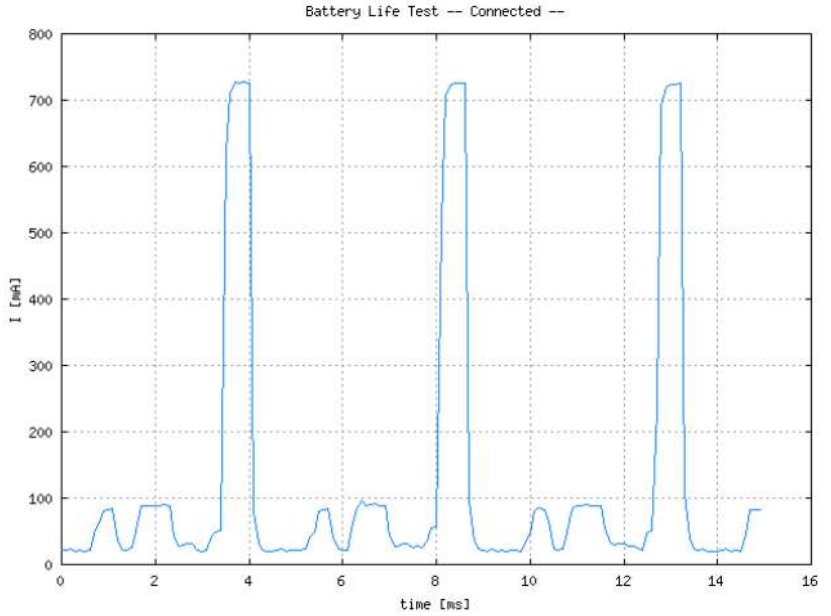
BAND: GSM1800
TEST SETTINGS:
DRX: 5
BA LIST arfcn: 512 530 560 580 610 640 670 700 720 740 760 790 810 840 860
PCL: 0




**GSM1800**

**Idle mode**

Average current:
1.69 mA

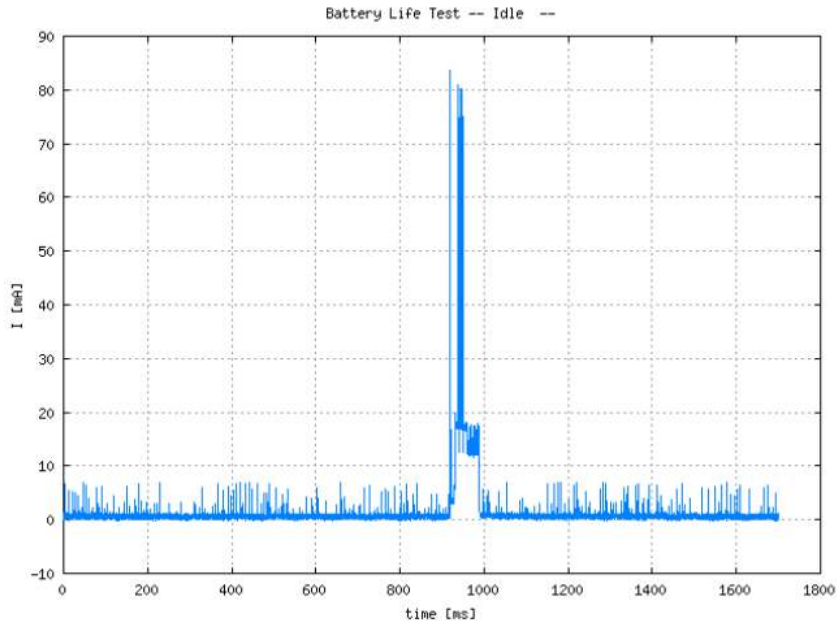



**GSM1800**

**Allocated mode**

Average current:
127.20 mA

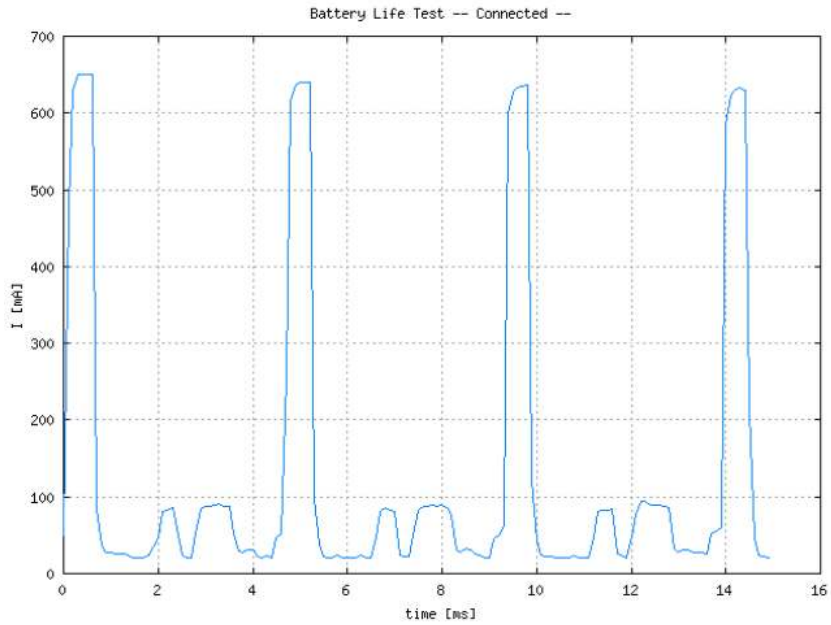
BAND: GSM1900
TEST SETTINGS:
DRX: 5
BA LIST arfcn: 512 530 550 570 590 610 630 650 670 690 710 730 750 770 790
PCL: 0




**GSM1900**

**Idle mode**

Average current:
2.02 mA




**GSM1900**

**Allocated mode**

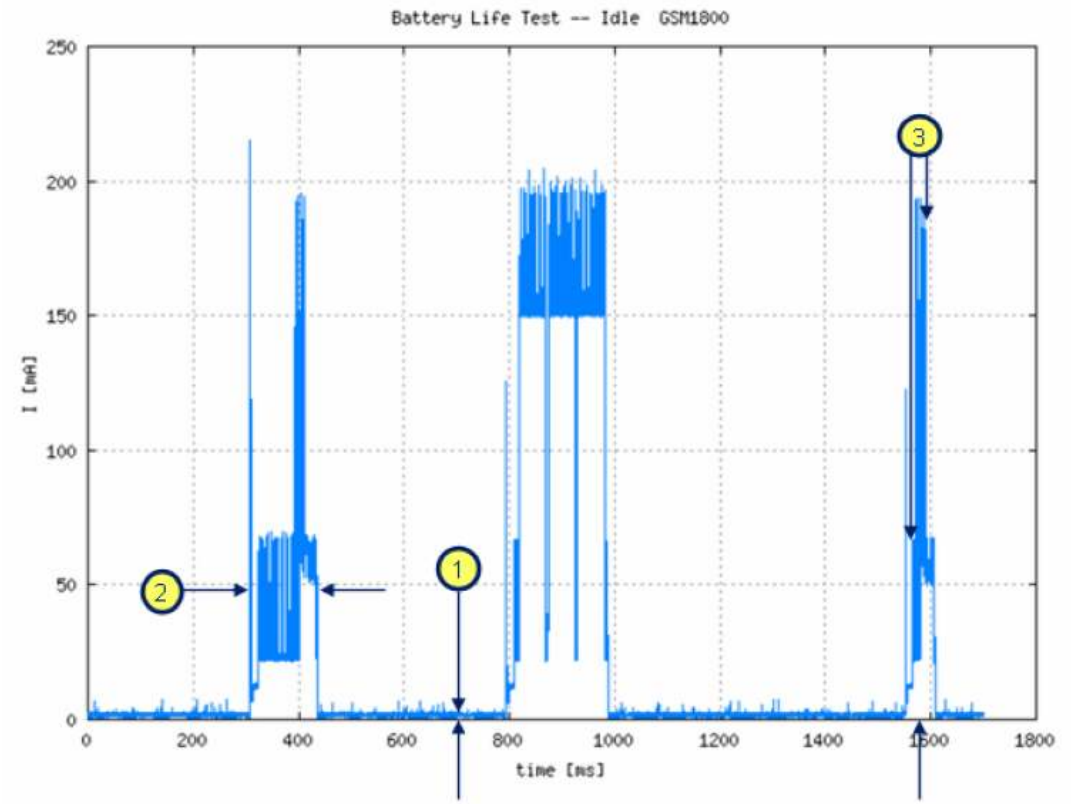
Average current:
113.85 mA

### 2.2.2.2 Power Saving

Power saving is a special function that allows the reducing of power consumption during the idle time. If the clock increases, required power increases too. Therefore a solution for minimizing the power is the reducing of the master clock frequency when there aren't activities. In this period the system doesn't work with a clock of 26 MHz ("fast clock") but with a clock of 32 KHz (RTC clock or "slow clock"). This switching between 26 MHz and 32 KHz clock is performed by SCCU (Standby Clock Control Unit).

Main priorities of power saving are the following:
1. Reduce base (min) current consumption.
2. Minimize full-speed running periods, minimize power saving on/off switching.
3. Reduce max current consumption.

These points are reported in the following figure:




### 2.2.3 GSM/GPRS modem functionalities

TM2 GSM/GPRS module integrates a full-featured R99 GSM-GPRS Protocol Stack, whose main characteristics are listed in the following. Refer to the Teltonika PICS/PIXIT documentation for a detailed description of the Stack features.

The module can be configured either dual-band or tri-band or quad-band. The product implements a quad-band MS able to operate in the frequency bands GSM 850 MHz, EGSM 900 MHz, DCS 1800 MHz and PCS 1900 MHz; the dynamic behavior can be configured dynamically by disabling/enabling a specific band e.g. through AT commands. The supported power classes for both voice and data services will be:

- Class 4 for GSM band.
- Class 1 for DCS bands.

The product implements a Class B Mobile Station; this means the data module can be attached to both GPRS and GSM services, using one service at a time. Network operation modes I to III are supported, with user-definable preferred service between GSM and GPRS. Optionally paging messages for GSM calls can be monitored during GPRS data transfer in not-coordinating network operation mode NOM II-III. PBCCH/PCCCH logical channels are supported, as well as CBCH reception. GPRS multislot 10 is implemented, implying a maximum of 4 slots in DL (reception) and 2 slots in UL (transmission) and 5 slots on the whole. Finally TM2 GSM/GPRS module supported:

- All coding schemes from CS1 to CS4.
- As for the circuit switched services, speech channel modes HR and FR version 1, 2 and 3 (FR, HR, EFR, N-AMR) are supported.
- Encryption algorithms A5/1 and A5/2 for GSM for GPRS are supported;
- CS Data calls are supported in transparent/non transparent mode up to 9.6 kbps.
- Bearer service fax Group 3 Class 2.0 is supported.

Among access interfaces to DTE, both V.32 and V.110 are provided.

### 2.2.4 Supplementary servines

The following supplementary services are provided:

- Call Hold (CH).
- Call Waiting (CW).
- Multi-Party (MTPY).
- Call Forwarding (CF).
- Explicit Call Transfer (ECT).
- Call Barring (CB).
- Calling Line Identification Presentation (CLIP).
- Calling Line Identification Restriction (CLIR).
- Connected Line Identification Presentation (COLP).
- Connected Line Identification Restriction (COLR).
- Unstructured Supplementary Services Data (USSD).

### 2.2.5 Short Message Service

Mobile-originated as well as mobile-terminated SMS are supported. Text and PDU mode are supported. Reception of SMS during circuit-switched calls is supported. Reception of SMS via GPRS is also supported. SMS SIM storage is provided.

### 2.2.6 SIM Functionality

Among SIM functionalities, the following services of the SIM are supported:

- Abbreviated Dialing Numbers (ADN).
- Fixed Dialing Numbers (FDN).
- Last Dialed Numbers (LDN).
- Service Dialing Numbers (SDN).
- ME Personalization (SIM Lock).

ME Personalization handling is a mechanism to tie the ME operation to one specific SIM card or to a limited range of SIM cards from a given Network Operator or Service Provider. The ME will only accept the SIM if there is a positive match between the personalization code group(s) stored in the ME and the code group(s) belonging to the inserted SIM. The SIM Lock feature supported by TM2 GSM/GPRS module enables ME personalization through the following personalization categories:

- Network lock.
- Network subset lock.
- Service provider lock.
- Corporate lock.
- Operator lock.

SIM Toolkit R 99 is supported. For a detailed description of the STK features, refer to the PICS/PIXIT documentation.

### 2.2.7 AT-command support

The modem functionalities and services are provided through a rich serial AT-command interface. All supported standard as well as proprietary AT commands are detailed in the table of SW interface.

### 2.2.8 Other basic features

Within the scope of the M2M or user interface, the following indications and functionalities are supported:

- Display of Called Number.
- Indication of Call Progress Signals.

- Country/PLMN Indication.
- Short Message Indication and Acknowledgement.
- International Access Function.
- Service Indicator.
- Dual Tone Multi Frequency (DTMF).
- Subscription Identity Management.
- Service Provider Indication.
- Abbreviated Dialing.
- Power on (external input).

# 3 User Interfaces

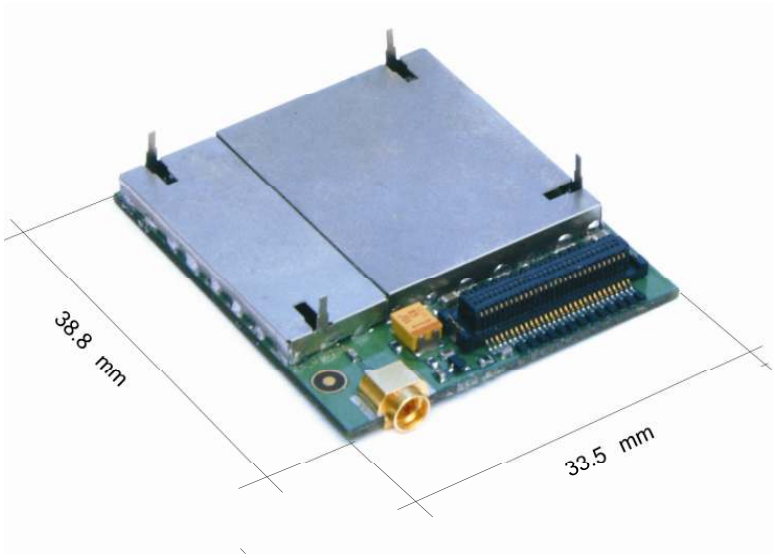
PIN OUT description A 60-pin connector is provided to interface of TM2 module for the power supply, SIM interface, audio interface (2 x analog, 1x digital), I2C bus, SPI bus, 2 x analog in (ADC), 2 x analog out (PWM), 2 UART serial ports, and 12 GPIOs (maximum number).

3.1 Table Pin Out Description

| PIN | Name | I/O | Function | I/O type | Description |
|---|---|---|---|---|---|
| 1 | VBAT | PWR | GSM Power Supply | From 3.3 to 4.3 V (Typ: 3.8 V) | Should be connected with pins 3, 5, 7 |
| 2 | GND | PWR | GSM Power Supply | Ground | Should be connected with pins 4, 6, 8 |
| 3 | VBAT | PWR | GSM Power Supply | From 3.3 to 4.3 V (Typ: 3.8 V) | Should be connected with pins 1, 5, 7 |
| 4 | GND | PWR | GSM Power Supply | Ground | Should be connected with pins 2, 6, 8 |
| 5 | VBAT | PWR | GSM Power Supply | From 3.3 to 4.3 V (Typ: 3.8 V) | Should be connected with pins 1, 3, 7 |
| 6 | GND | PWR | GSM Power Supply | Ground | Should be connected with pins 2, 4, 8 |
| 7 | VBAT | PWR | GSM Power Supply | From 3.3 to 4.3 V (Typ: 3.8 V) | Should be connected with pins 1, 3, 5 |
| 8 | GND | PWR | GSM Power Supply | Ground | Should be connected with pins 2, 4, 6 |
| 9 | VCHARGE | PWR | GSM Power Supply | 0 - 12V (Typ: 6V) Current limited to 600 mA | Should be connected with pin 11 |
| 10 | DCD | O | Asynchronous Serial Interface 0 | CMOS 3.3V compatible | Data Carrier Detect |
| 11 | VCHARGE | PWR | GSM Power Supply | 0 - 12V (Typ: 6V) Current limited to 600 mA | Should be connected with pin 9 |
| 12 | DTR | I | Asynchronous Serial Interface 0 | CMOS 3.3V compatible | Data Terminal Ready |
| 13 | SIM_VCC | I/O | SIM interface | Supply 1.8V-3.3V | SIM power supply |
| 14 | CTS_0 | I | Asynchronous Serial Interface 0 | CMOS 3.3V compatible | Clear To Send |
| 15 | SIM_IO | I/O | SIM interface | CMOS 3.3V compatible | SIM I/O serial data |
| 16 | RTS_0 | O | Asynchronous Serial Interface 0 | CMOS 3.3V compatible | Request to Send |
| 17 | SIM_CLK | O | SIM interface | CMOS 3.3V compatible | SIM clock signal |
| 18 | RXD_0 | I | Asynchronous Serial Interface 0 | CMOS 3.3V compatible | Receive Serial Data |
| 19 | SIM_RST | O | SIM interface | CMOS 3.3V compatible | SIM reset signal |
| 20 | TXD_0 | O | Asynchronous Serial Interface 0 | CMOS 3.3V compatible | Transmit Serial Data |
| 21 | MRST0/GPIO | I/O | Synchronous Serial Interface (SPI compatible) | CMOS 3.3V compatible | Master Receive Slave Transmit |
| 22 | RI | O | Asynchronous Serial Interface 0 | CMOS 3.3V compatible | Ring Indicator |

| | | | | | |
|---|---|---|---|---|---|
| 23 | MTSR0/GPIO | I/O | Synchronous Serial Interface (SPI compatible) | CMOS 3.3V compatible | Master Transmit Slave Receive |
| 24 | DSR | O | Asynchronous Serial Interface 0 | CMOS 3.3V compatible | Data Set Ready |
| 25 | SCLK0/GPIO | I/O | Synchronous Serial Interface (SPI compatible) | CMOS 3.3V compatible | Shift Clock |
| 26 | RXD_1 | I | Asynchronous Serial Interface 1 | CMOS 3.3V compatible | Receive Serial Data |
| 27 | SCL/GPIO | O | I2C bus interface | CMOS 3.3V compatible | Serial Clock Line |
| 28 | TXD_1 | O | Asynchronous Serial Interface 1 | CMOS 3.3V compatible | Transmit Serial Data |
| 29 | SDA/GPIO | I/O | I2C bus interface | CMOS 3.3V compatible | Serial Data Line |
| 30 | KEYOUT 0/GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad output pin 0 / GPIO 00 |
| 31 | CLK0_DAI/GPIO | I/O | Digital Audio Interface | CMOS 3.3V compatible | DAI Clock |
| 32 | KEYOUT 1/GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad output pin 1 / GPIO 50 |
| 33 | RXD_DAI /GPIO | I | Digital Audio Interface | CMOS 3.3V compatible | DAI Receive |
| 34 | KEYOUT 2/GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad output pin 2 / GPIO 01 |
| 35 | TXD_DAI /GPIO | O | Digital Audio Interface | CMOS 3.3V compatible | DAI Transmit |
| 36 | KEYOUT 3/GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad output pin 3 / GPIO 02 |
| 37 | WA0_DAI /GPIO | I/O | Digital Audio Interface | CMOS 3.3V compatible | DAI Reset |
| 38 | KEYOUT 4/GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad output pin 4 / GPIO 03 |
| 39 | EXTRSTn | I | External reset | CMOS 3.3V compatible | External HW reset |
| 40 | KEYOUT 5/GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad output pin 5 / GPIO 04 |
| 41 | MICP1 | I | Audio Interface | Analog | Handset microphone reference |
| 42 | KEYIN0/ GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad input pin 0 / GPIO 05 |
| 43 | MICN1 | I | Audio Interface | Analog | Handset microphone bias |
| 44 | KEYIN1/ GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad input pin 1 / GPIO 06 |
| 45 | EPPA1B | O | Audio Interface | Analog | Balanced audio out |
| 46 | KEYIN2/ ON | I/O | Keypad interface / Power on | CMOS 3.3V compatible | Keypad input pin 2 / Power on button /GPIO 07 |
| 47 | EPPA2A | O | Audio Interface | Analog | Balanced audio out |
| 48 | KEYIN3/ GPIO | I/O | Keypad interface / GPIO | CMOS 3.3V compatible | Keypad input pin 3 / GPIO 08 |
| 49 | MICP2 | I | Audio Interface | Analog | Handset microphone reference |
| 50 | CAP19/GPIO | I/O | Capture Compare / GPIO | CMOS 3.3V compatible | Capture Compare 19 / GPIO 47 |
| 51 | MICN2 | I | Audio Interface | Analog | Handset microphone bias |

| | | | | | |
|---|---|---|---|---|---|
| 52 | CAP02/GPIO | I/O | Capture Compare / GPIO | CMOS 3.3V compatible | Capture Compare 02 / GPIO 57 |
| 53 | AUOP | O | Audio Interface | Analog | Balanced power audio out |
| 54 | CAP05/GPIO | I/O | Capture Compare / GPIO | CMOS 3.3V compatible | Capture Compare 05 / GPIO 28 |
| 55 | AUON | O | Audio Interface | Analog | Balanced power audio out |
| 56 | CAP06/GPIO | I/O | Capture Compare / GPIO | CMOS 3.3V compatible | Capture Compare 06 / GPIO 30 |
| 57 | ADC1 | I | Measurement interface | ADC 12bits 0-2.5V | Analog to Digital Converter |
| 58 | CAP00_EX5IN/GPIO | I/O | Capture Compare / GPIO / External Interrupt | CMOS 3.3V compatible | Capture Compare 00 / GPIO 30 / Ext Int 5B |
| 59 | ADC2 | I | Measurement interface | ADC 12bits 0-2.5V | Analog to Digital Converter |
| 60 | CAP22_EX3IN/GPIO | I/O | Capture Compare / GPIO / External Interrupt | CMOS 3.3V compatible | Capture Compare 22 / GPIO 55 / Ext Int 3 |




3.1 Fig. TM2 module

## 3.1 SIM Interface

TM2 module can be equipped with an on-board SIM connector or an external SIM connector. High-speed SIM/ME interface is implemented. Both 1.8V and 3V SIM type will be supported (1.8/3V ME); activation and deactivation with automatic voltage switch from 1.8V to 3V are implemented, according to ISO-IEC 78-16-e Specifications. The SIM driver supports the PPS (Protocol and Parameter Selection) procedure for baud-rate selection, according to the values proposed by the SIM Card. Clock stop is supported at both high and low level. Finally, external SIM ESD protection is required.

| Name | PIN # | I/O | I/O type | Description |
|---|---|---|---|---|
| SIM_VCC | 13 | I/O | Supply 1.8V 3.3V | SIM Power Supply |
| SIM_IO | 15 | I/O | CMOS 3.3V compatible | SIM I/O Serial Data |
| SIM_CLK | 17 | O | CMOS 3.3V compatible | SIM Clock Signal |
| SIM_RST | 19 | O | CMOS 3.3V compatible | SIM Reset Signal |

## 3.2 Battery

The supported type for the battery shall be Li-Ion rechargeable only; default system will support 650mAh nominal. Protection circuitry is integrated on the module. The Battery/Charger functionality provides:

- battery charging control, i.e. constant voltage charging and trickling of charging in order to maintain the full capacity of the battery;
- pulse charge mode, to improve capacity estimation accuracy;
- capacity estimation during charging, no charging, ongoing calls, etc., constantly considering the different load parameters of the phone;
- Measurements of battery voltage, RF and battery temperature, equipment status, etc.

Charging of deeply discharged battery as well as charging during phone call is possible.

The module has a current consumption lower than 3mA during idle mode reception, lower than 300 mA in connected mode on GSM band and lower than 180mA in connected mode on DCS band (measurements are performed following the GSM Association Battery Life Measurement Technique Document). The charging battery range goes from 400 to 1100 mA with a step of 100 mA.

| Name | PIN # | I/O | I/O type | Description |
|---|---|---|---|---|
| VBAT | 1 | PWR | From 3.3 to 4.3 V (Typ: 3.8 V) | Should be connected with pins 3, 5, 7 |
| GND | 2 | PWR | Ground | Should be connected with pins 4, 6, 8 |
| VBAT | 3 | PWR | From 3.3 to 4.3 V (Typ: 3.8 V) | Should be connected with pins 1, 5, 7 |
| GND | 4 | PWR | Ground | Should be connected with pins 2, 6, 8 |
| VBAT | 5 | PWR | From 3.3 to 4.3 V (Typ: 3.8 V) | Should be connected with pins 1, 5, 7 |
| GND | 6 | PWR | Ground | Should be connected with pins 2, 4, 8 |
| VBAT | 7 | PWR | From 3.3 to 4.3 V (Typ: 3.8 V) | Should be connected with pins 1, 5, 7 |
| GND | 8 | PWR | Ground | Should be connected with pins 2, 4, 6 |
| VCHARGE | 9 | PWR | From 0 to 12 V (Typ: 6V)<br>Current limited to 600 mA | Should be connected with pin 11 |
| VCHARGE | 11 | PWR | From 0 to 12 V (Typ: 6V)<br>Current limited to 600 mA | Should be connected with pin 9 |

## 3.3 Antenna interface

A 50 Ohm MMCX connector is provided as antenna connector for GSM functionality.

## 3.4 Asynchronous Serial interface

Two serial ports (ASC0 UART and ASC1 UART) are supported working at the selected baud rate (default 115.2 kbps): on ASC0 complete 9 pin serial port is supported and power saving wakeup is available. This interface is fullyRS232 9-pin logical compliant and support full HW flow control. Default UART configuration implies ASC0 devoted to AT interface, ASC1 available for debug/tracing (only RX/TX lines). These serial interfaces are available complying with V.24 protocol and the signals are:

- TX Data (TXD_0).
- RX Data (RXD_0).
- Request to Send (RTS_0).
- Clear to Send (CTS_0).
- Data Terminal Ready (DTR).
- Data Set Ready (DSR).

To avoid floating if output pins are high-impedance, use pull-up resistors tied to GSM_VDD or pull-down resistors tied to GND. The first 6 pin reported in the table refer at the first serial interface, while the last two refer at the second serial interface.

| Name | PIN # | I/O | I/O type | Description | Serial interface # |
|---|---|---|---|---|---|
| DCD | 10 | O | CMOS 3.3V compatible | Data Carrier Detect | Asynchronous Serial Interface 0 |
| DTR | 12 | I | CMOS 3.3V compatible | Data Terminal Ready | |
| CTS_0 | 14 | I | CMOS 3.3V compatible | Clear To Send | |
| RTS_0 | 16 | O | CMOS 3.3V compatible | Request to Send | |
| RXD_0 | 18 | I | CMOS 3.3V compatible | Receive Serial Data | |
| TXD_0 | 20 | O | CMOS 3.3V compatible | Transmit Serial Data | |
| RI | 22 | O | CMOS 3.3V compatible | Ring Indicator | |
| DSR | 24 | O | CMOS 3.3V compatible | Data Set Ready | |
| RXD_1 | 26 | I | CMOS 3.3V compatible | Receive Serial Data | Asynchronous Serial Interface 1 |
| TXD_1 | 28 | O | CMOS 3.3V compatible | Transmit Serial Data | |

## 3.5 GPIO

All General Purpose I/O (GPIOs) shall be initialized to proper direction / output logic level as soon as possible. If supply is removed from external device, relevant GPIOs should be placed at low logic level, or decoupled.

| Name | PIN # | I/O | I/O type | Description |
|---|---|---|---|---|
| KEYOUT0/GPIO | 30 | I/O | CMOS 3.3V compatible | Keypad output pin 0 / GPIO 00 |
| KEYOUT1/GPIO | 32 | I/O | CMOS 3.3V compatible | Keypad output pin 1 / GPIO 50 |
| KEYOUT3/GPIO | 36 | I/O | CMOS 3.3V compatible | Keypad output pin 3 / GPIO 02 |
| KEYOUT4/GPIO | 38 | I/O | CMOS 3.3V compatible | Keypad output pin 4 / GPIO 03 |
| KEYOUT5/GPIO | 40 | I/O | CMOS 3.3V compatible | Keypad output pin 5 / GPIO 04 |
| KEYIN0/GPIO | 42 | I/O | CMOS 3.3V compatible | Keypad input pin 0 / GPIO 05 |

| | | | | |
|---|---|---|---|---|
| KEYIN1/GPIO | 44 | I/O | CMOS 3.3V compatible | Keypad input pin 1 / GPIO 06 |
| KEYIN3/GPIO | 48 | I/O | CMOS 3.3V compatible | Keypad input pin 3 / GPIO 08 |
| CAP19/GPIO | 50 | I/O | CMOS 3.3V compatible | Capture Compare 19 / GPIO 47 |
| CAP02/GPIO | 52 | I/O | CMOS 3.3V compatible | Capture Compare 02 / GPIO 57 |
| CAP05/GPIO | 54 | I/O | CMOS 3.3V compatible | Capture Compare 05 / GPIO 28 |
| CAP06/GPIO | 56 | I/O | CMOS 3.3V compatible | Capture Compare 06 / GPIO 30 |

**Note:** The General Purpose I/O is not accessible using AT commands. It could be accessible from internal M2M resusrses only.

## 3.6 SW interfaces

The AT-command interface provides the service and the functionalities of GSM/GPRS modem. It is possible observe the AT commands of TM2 module in the following table.

| Name | Command description |
|---|---|
| *General Commands* | |
| AT+CGMI | Manufacturer identification |
| AT+CGMM | Request model identification |
| AT+CGMR | Request revision identification |
| AT+CGSN | Request product serial number identification |
| AT+CSCS | Set TE character set |
| AT+CIMI | Request international mobile subscriber identification |
| AT+CCID | Card identification |
| AT+GCAP | Request complete capability list |
| A/ | Repeat last command |
| *Mobile equipment control and status commands* | |
| AT+CPAS | Phone activity status |
| AT+CPWROFF | Switch off the MS |
| AT+CFUN | Set phone functionality |
| AT+CBC | Battery charge |
| AT+CIND | Indicator control |
| AT+CMER | Mobile termination event reporting |
| AT+CCLK | Clock |
| AT+CALA | Alarm |
| AT+CRSM | Restricted SIM access |
| AT+CALM | Alert sound mode |
| AT+CRSL | Ringer sound level |
| AT+CLVL | Loudspeaker volume level |
| AT+CMUT | Mute control |
| AT+CCWE | Call meter maximum event |
| AT+CSGT | Set greeting text |
| AT+CALD | Delete alarm |
| AT+CTZU | Automatic Time Zone Update |
| AT+CTZR | Time Zone Reporting |

| | |
|---|---|
| AT+CLAC | List all available AT commands |
| AT+CMEE | Report mobile termination error |

*Call control commands*

| | |
|---|---|
| AT+CSTA | Select type of address |
| ATD | Dial command (full support of modifiers: ;„>,I,G) |
| ATT | Select tone dialing |
| ATP | Select pulse dialing |
| ATA | Call answer |
| ATH | Hook control |
| ATM | Monitor speaker mode |
| ATL | Monitor speaker loudness |
| AT+CMOD | Call mode |
| AT+CHUP | Hang up call |
| AT+CEER | Extended error report |
| AT+VTD | Tone duration |
| AT+VTS | DTMF and tone generation |
| ATDL | Redial last telephone number |
| ATS0 | Automatic answer |

*Network service commands*

| | |
|---|---|
| AT+CNUM | Subscriber number |
| AT+CSQ | Signal quality |
| AT+COPS | Operator selection |
| AT+CREG | Network registration |
| AT+CPOL | Preferred operator list |
| AT+COPN | Read operator names |

*Security commands*

| | |
|---|---|
| AT+CPIN | Enter PIN |
| AT+CLCK | Facility lock |
| AT+CPWD | Change password |

*Phonebook commands*

| | |
|---|---|
| AT+CPBS | Select phonebook memory storage |
| AT+CPBR | Read phonebook entries |
| AT+CPBF | Find phonebook entries |
| AT+CPBW | Write phonebook entry |

*Short message commands*

| | |
|---|---|
| AT+CSMS | Select message service |
| AT+CPMS | Preferred message storage |
| AT+CMGF | Preferred message format |
| AT+CSAS | Save settings |
| AT+CRES | Restore settings |
| AT+CSDH | Show text mode parameters |
| AT+CNMI | New message indication |
| AT+CMGR | Read message |
| AT+CNMA | New message acknowledgement to ME/TA |
| AT+CMGL | List message |
| AT+CMGS | Send message |
| AT+CMGW | Write message to memory |
| AT+CMSS | Send message from storage |

| | |
|---|---|
| AT+CSMP | Set text mode parameters |
| AT+CMGD | Delete SMS |
| AT+CSCA | Service center address |
| AT+CSCB | Select cell broadcast message types |

*Supplementary services commands*

| | |
|---|---|
| AT+CCFC | Call forwarding |
| AT+CCWA | Call waiting |
| AT+CLIR | Calling line identification restriction |
| AT+CLIP | Calling line identification presentation |
| AT+COLP | Connected line identification presentation |
| AT+COLR | Connected line identification restriction |
| AT+CAOC | Advise of charge |
| AT+CACM | Accumulated call meter |
| AT+CAMM | Accumulated call meter maximum |
| AT+CPUC | Price per unit and currency table |
| AT+CHLD | Call related supplementary services |
| AT+CTFR | Call deflection |
| AT+CLCC | List current list calls |
| AT+CSSN | Supplementary service notifications |
| AT+CUSD | Unstructured supplementary service data |
| AT+CCUG | Closed user group |
| AT+CNAP | Calling name presentation |

*Data commands*

| | |
|---|---|
| AT+CBST | Select bearer service type |
| AT+FCLASS | Service class selection and identification |
| AT+CR | Service reporting control |
| AT+CRC | Cellular result codes |
| AT+CRLP | Radio link protocol |

*FAX class 2.0 commands*

| | |
|---|---|
| AT+FDT | Transmit data |
| AT+FDR | Receive data |
| AT+FIP | Initialize facsimile parameters |
| AT+FKS | Session termination |
| AT+FK | Session termination |
| AT+FAA | Adaptive answer |
| AT+FAP | Address & polling capabilities |
| AT+FBS | Buffer size |
| AT+FBO | Data bit order |
| AT+FBU | HDLC frame reporting |
| AT+FCC | DS capabilities parameters |
| AT+FCQ | Copy quality checking |
| AT+FCR | Capability to receive data |
| AT+FCS | Current session results |
| AT+FCT | DTE phase C response timeout |
| AT+FEA | Phase C received EOL alignment |
| AT+FFC | Format conversion |
| AT+FHS | Call termination status |
| AT+FIE | Procedure interrupt enable |

| | |
|---|---|
| AT+FIS | Current session parameters |
| AT+FIT | Inactivity timeout |
| AT+FLI | Local ID string |
| AT+FLO | Set flow control |
| AT+FLP | Indicate document to poll |
| AT+FMI | Request manufacturer identification |
| AT+FMM | Request model identification |
| AT+FMR | Request revision identification |
| AT+FMS | Minimum phase C speed |
| AT+FNR | Negotiation reporting |
| AT+FNS | Non-standard frame FIF octet string |
| AT+FND | NSF message data indication |
| AT+FPA | Selective polling address |
| AT+FPI | Local polling ID string |
| AT+FPP | Packet protocol control |
| AT+FPS | Page status |
| AT+FPW | Password parameter |
| AT+FRQ | Receive quality thresholds |
| AT+FRY | Error correction mode retry count |
| AT+FSA | Sub Address parameter |
| AT+FSP | Request to poll |

*V.24 control and V.25ter commands*

| | |
|---|---|
| ATZ | Reset to default configuration |
| AT&F | Set to factory defined configuration |
| AT&C | Circuit 109 (CD) behavior |
| AT&D | Circuit 108/2 (DTR) behavior |
| AT&S | DSR override |
| AT&K | Flow control |
| AT&W | Store current configuration |
| AT&V | Display current configuration |
| AT&Y | Designate a default reset profile |
| ATI | Request identification information |
| AT+GMI | Request manufacturer identification |
| AT+GMM | Request model identification |
| AT+GSN | Request product serial number identification |
| AT+GMR | Request revision identification |
| AT+ICF | DTE-DCE character framing |
| AT+IFC | DTE-DCE local flow control |
| AT\Q | Set flow control |
| AT+IPR | Fixed DTE rate |
| ATO | Return to on-line data state |
| ATS2 | Escape character |
| ATS3 | Command line termination character |
| ATS4 | Response formatting character |
| ATS5 | Command line editing character |
| ATS6 | Pause before blind dialing |
| ATS7 | Connection completion timeout |
| ATS8 | Command dial modifier time |
| ATS10 | Automatic disconnect delay |

| | |
|---|---|
| ATS12 | Escape prompt delay (EPD) |
| ATE | Command echo |
| ATQ | Result code suppression |
| ATV | DCE response format |
| ATX | Result code selection and call progress monitoring control |

*Specific AT commands*

| | |
|---|---|
| AT# | Production test command |
| AT+CGED | GPRS cell environment description |
| AT+TRACE | Switch on/off trace |
| AT+XBANDSEL | Select band |
| AT+XCALLSTAT | Set reporting call status |
| AT+XGENDATA | Display generation and SW version |
| AT+XGCNTRD | Read counters of sent or received GPRS data |
| AT+XGCNTSET | Set/reset counter of sent or received GPRS data |
| AT+XHANDSFREE | Set hands free mode |
| AT+XL1SET | Call the L1-specific function |
| AT+XSIO | Configuration trace and modem (AT) interfaces |
| AT+NADC | ADC read command |
| AT+NGPIOC | GPIO select configuration command |
| AT+NGPIOR | GPIO read command |
| AT+NGPIOW | GPIO set command |
| AT+NRNG | Ringer select command |

*SIM toolkit*

| | |
|---|---|
| AT+STKPRO | SIM-APPL-TK proactive commands |
| AT+STKTR | SIM-APPL-TK terminal response |
| AT+STKENV | SIM-APPL-TK envelope |
| AT+STKPROF | SIM-APPL-TK terminal profile |
| AT+STKCC | SIM-APPL-TK call control commands |
| AT+STKCNF | SIM-APPL-TK proactive session status |

*GPRS AT commands*

| | |
|---|---|
| AT+CGDCONT | Define PDP context |
| AT+CGEREP | GPRS event reporting |
| AT+CGQREQ | Quality of service profile (requested) |
| AT+CGQMIN | Quality of service profile (minimum acceptable) |
| AT+CGATT | GPRS attach or detach |
| AT+CGACT | PDP context activate or deactivate |
| AT+CGDATA | Enter data state |
| AT+CGAUTO | Automatic response to a network request for PDP context activation |
| AT+CGPADDR | Show PDP address |
| AT+CGCLASS | GPRS mobile station class |
| AT+CGREG | GPRS network registration status |
| AT+CGSMS | Select service for MO SMS messages |

## 3.7 Audio devices

### 3.7.1 Handset

A standard handset is supported for normal handset operation on the default audio path.

### 3.7.2 Headset

One earpiece headset is supported and may be used for voice during calls. The audio path switching from handset to headset is automatic when a rising edge is detected from line CAP22_EX3XIN (Pin 60); the audio path returning to the headset when line CAP22_EX3XIN (Pin 60) return to 0 level.

### 3.7.3 Microphone

The uplink path can be switched between the handset and the headset microphone. The path switching is driven automatically as described above for the earpiece. The uplink path can be muted.

### 3.7.4 Hands-free

A true hands-free functionality is implemented using high power loudspeaker, MS microphone and appropriate DSP algorithms for voice band handling (Echo canceller and Automatic Gain control). The product is equipped with a power audio amplifier that can drive an external 8 ohm speaker with 400mW peak. The audio power amplifier can be used as a voice amplifier for the hands free functionality and as a melody player amplifier for ringer functionality. The melody player could be the Midi synthesizer or the tone generator. In order to minimize the clipping of the audio signal, the polarization voltage can be adapted to the voltage supply (battery voltage). The audio signal on the loudspeaker is a mono signal.

### 3.7.5 Polyphonic ringer

Polyphonic ring-tones can be generated by an internal MIDI synthesizer, which runs at 16 or 32 KHz sample frequency and can sum up to 40 voices at 16 kHz sampling rate.

The synthesizer output is only mono and cannot be mixed with TCH voice path (the two are mutually exclusive). To perform in-band alerting during TCH with voice path open, only Tone Generator can be used. The output samples of the synthesizer are post processed by two modules:

• High Frequency Shelving Filter: This module is implemented as a first order IIR Filter, which is mainly used for high frequency boost in audio signals. Its transfer function can be controlled by 4 filter coefficients.

• Audio Compressor: The audio compressor is a device for manipulating the dynamic range of mono or stereo audio signals. The audio compressor can be controlled by 14 configuration parameters. Polyphonic standard format supported.

The MIDI driver can play:

• MIDI files conforming to:
  - General Midi Level 1.0 with file-format 0 and 1.
  - General Midi Lite 1.0.
• SPMidi (Scalable Polyphony MIDI) files conforming to:
  - SPMidi 1.0.
• iMelody files conforming to:

- iMelody v.1.2 specifications.

### 3.7.6 ADC interface / Measurement interface

2 inputs for Analog-to-Digital Converter are supported. The resolution of these converters is of 12-bit with a range of 0-2.5 Volt.

| Name | PIN | I/O | I/O type | Description |
|---|---|---|---|---|
| ADC1 | 57 | I | ADC 12bits 0-2.5V | Analog to Digital Converter |
| ADC2 | 59 | I | ADC 12bits 0-2.5V | Analog to Digital Converter |

### 3.7.7 SPI

The SPI bus includes a clock signal, and two signals for the transmissions of the master and the slave.

| Name | PIN | I/O | I/O type | Description |
|---|---|---|---|---|
| MRST0/GPIO | 21 | I/O | CMOS 3.3V compatible | Master Receive Slave Transmit |
| MTSR0/GPIO | 23 | I/O | CMOS 3.3V compatible | Master Transmit Slave Receive |
| SCLK0/GPIO | 25 | I/O | CMOS 3.3V compatible | Shift Clock |

### 3.7.8 I2C bus interface

The I2C bus interface includes a serial clock and a serial data line.

| Name | PIN | I/O | I/O type | Description |
|---|---|---|---|---|
| SCL/GPIO | 27 | O | CMOS 3.3V compatible | Serial Clock Line |
| SDA/GPIO | 29 | I/O | CMOS 3.3V compatible | Serial Data Line |